



**Clark County NPDES
Long-term Index Site Project**

Quality Assurance Project Plan

Version 2.0 November 2004

Project Name: Long-term Index Site Project
Project Code: LISP
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Purpose of the Quality Assurance Project Plan

Clark County Public Works Water Resources (Water Resources) follows the general Quality Assurance Project Plan (QAPP) format defined by the State of Washington Department of Ecology (Ecology) (Lombard and Kirchmer, 2001). Water Resources requires a QAPP for each monitoring project. The plan addresses project design, schedule, methods of data collection and management, quality assurance and quality control requirements, data analysis, and reporting.

Background and Problem Statement

Background

The LISP fills a need for a project to observe and describe changes in stream health. It is designed to satisfy requirements of the county's 1999 NPDES municipal stormwater permit conditions S5.B.4. and S9.C.5. to describe watershed conditions, evaluate overall program effectiveness, and assess the degree to which stormwater influences water bodies. The LISP is also intended to help meet expected requirements under future permits to analyze long-term trends in water body condition.

In addition to mandated NPDES requirements, the Board of Clark County Commissioners (BOCC) and the county's Clean Water Commission (CWC) have made clear statements requesting scientifically defensible information about stream health status and trends. Long-term monitoring provides a basis for determining whether overall policy approaches for improving water body health are achieving measurable results.

Stream health "indicators" are measurable parameters, or groups of parameters, which describe stream health. They fall into several major categories, including biological parameters, physical habitat, physicochemical water quality, and hydrology. The LISP utilizes selected indicator parameters from the first three categories, with the intent of identifying long term trends at a set of index sites typical of Clark County waterbodies. Hydrologic monitoring at the LISP stations is performed as part of a separate project and is addressed in the Clark County Hydrology Monitoring Project QAPP (September 2003).

Problem Statement

Stormwater-influenced or dominated streams can act as an integrated indicator of human-caused changes to waterbody health. There is little historical information describing the condition of these smaller, stormwater runoff-conveying streams in Clark County. Many of these streams have been impacted by human activities and exhibit water quality degradation, hydrologic modifications, and habitat alterations, but few data exist to systematically document current conditions or trends in stream condition. The LISP addresses this information gap by providing information describing trends in stream condition at ten sites in Clark County.

Clark County Clean Water Program

The Clark County Clean Water Program was initiated in the year 2000 to increase protection for streams, lakes, and groundwater. The program began in response to the increasing need for stewardship of local resources, as well as federal and state mandates for local government agencies to better control and clean stormwater runoff. The Clean Water Fee paid by property owners in unincorporated Clark County supports the enhanced levels of service required to accomplish Clean Water Program goals.

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The Clean Water Program is committed to building and implementing a comprehensive monitoring program that supports efforts to:

- Identify water quality problems and their sources
- Document existing health of our lakes and streams and track long-term changes
- Plan appropriate projects to improve water quality
- Demonstrate compliance with the county's National Pollutant Discharge Elimination System (NPDES) permit for the stormwater system

The LISP helps fulfill the requirement for receiving-water characterization identified under the County's NPDES stormwater permit, and is a primary mechanism through which we document the existing and long-term health of local streams.

QAPP revision

This document replaces the original QAPP which was completed in October 2002. Modifications to the scope, objectives, and procedures since 2002 necessitate an update to the QAPP to reflect current and future monitoring activities. This QAPP and future revisions or addendums apply to all monitoring under the LISP beginning in January 2004.

Organization and Timeline

Project Staff

LISP activities are administered through Clark County Public Works Water Resources as part of the county's NPDES Clean Water Program.

Client:	Earl Rowell, Water Resources manager
Supervisor:	Rod Swanson, Senior Planner
Project Manager:	Jeff Schnabel, Planner III (Water Resource Scientist)
QC Coordinator:	Ron Wierenga, Engineer II (Water Resource Scientist)
Project Team:	Jeff Schnabel Ron Wierenga Water Resources Technician Bob Hutton, Planner III (Water Resource Scientist) Clark County Volunteer Monitoring Program

Laboratory Contracts

Laboratory water quality analyses for the project are performed by North Creek Analytical Laboratories (NCA), a Washington Department of Ecology (Ecology) accredited laboratory located in Beaverton, Oregon. Benthic macroinvertebrate samples are analyzed by Rhithron Biological Associates in Missoula, Montana. Contact information is listed below. Laboratories may change based on price quotes from qualified labs, or as project needs evolve.

Howard Holmes or Mary Fritzman-Smith
North Creek Analytical
9405 SW Nimbus Avenue
Beaverton, OR 97008-7132
503-906-9200

Wease Bollman
Rhithron Biological Associates
1501 W. Central Avenue
Missoula, MT 59801
406-721-1977

Budget

The project budget is derived from stormwater fees under the following coding:
4420-000-531-534-203 RC# 011161. Budget estimates for the LISP are found in Table 1.

Table 1: LISP budget estimate

Budget Category	Water Quality Monitoring (grabs/temperature loggers)	Benthic Macroinvertebrates	Habitat
<i>Interval</i>	<i>Annual</i>	<i>Annual</i>	<i>5-year interval</i>
Field time	\$13,000	\$6000	\$27,000
Vehicle	\$800	\$150	\$300
Laboratory	\$12,600	\$2255	
Sample shipping		\$500	
Equipment maintenance	\$3700	\$500	\$500
Data management	\$5400	\$2300	\$4500
Reporting	\$4500	\$4500	\$23,000 (includes 5-year technical report)
Contingency	\$2000	\$2000	\$2000
Total	\$42,000/year	\$18,200/year	\$57,300/ 5 years

For the five-year project cycle, which includes five years of water quality monitoring, five years of benthic macroinvertebrate collection, and one year of habitat surveys, the estimated project cost is \$360,000 (approximately \$72,000/year). Habitat survey cost may change substantially if field work is performed under contract by an outside consultant.

Project Timeline

The LISP is an ongoing ambient monitoring project intended to provide data over an extended time period. The project is designed to collect data at a temporal scale appropriate for long-term trend analysis as well as short-term assessment of stream conditions.

Water quality grabs are collected monthly on a continual basis, and benthic macroinvertebrate collection occurs once each year from July through October. Temperature loggers are deployed annually from May through September. Habitat surveys are conducted once every five years.

Brief annual data reports will include data collected during each year. Technical reports will be produced on a five-year cycle coinciding with habitat surveys. The next technical report will be produced following habitat data collection in 2007.

Project Description

Goals and Decision Statement

LISP data are used to assess current stream health and define long-term trends in stream condition at the project stations. Criteria for these determinations include 1) comparison of physicochemical data to water quality standards and aquatic life criteria; 2) calculation of statistical trends based on the long-term dataset, 3) comparison of benthic macroinvertebrate and habitat data to aquatic life criteria and 4) comparison of stream characteristics to historical data and regional expectations.

Clark County NPDES Long-Term Index Site Project: QAPP

Objectives

The primary objectives of the Long-term Index Site Project are to:

- Assess overall stream health in terms of water quality criteria and beneficial use support
- Identify and describe trends in stream health using a variety of physicochemical, biological and physical habitat indicators.
- Disseminate accurate information to local and state agencies, the general public, and other stakeholders

Physicochemical water quality objectives

The primary objectives of this component are to describe current stream conditions and trends using physicochemical indicators. Results indicate whether water quality complies with applicable state criteria, characterize overall water quality through calculation of the Oregon Water Quality Index (OWQI), and provide the means to describe changes in condition over an extended time period. Temperature data loggers are deployed to provide continuous temperature data during summer. These data are used primarily for comparison with state water quality criteria and aquatic life use requirements. Bacteria samples are collected as an indicator of potential human health risk and for comparison with state water quality criteria.

Standard procedures are described in the county's Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002).

Volunteer monitors collect the required monthly physicochemical water quality samples four times per year at two of the LISP stations (MIL010 and BRZ010). County staff collect these samples if volunteers are unable to visit the station.

Benthic Macroinvertebrate objectives

The primary objectives of this component are to describe current stream conditions and trends using biological indicators. Results provide an indication of whether significant habitat limitations are present, serve to characterize baseline conditions, and provide the means to describe changes in condition over an extended time period.

Benthic macroinvertebrate samples are collected following the procedures described in Ecology's Instream Biological Assessment Monitoring Protocols: Benthic Macroinvertebrates (Plotnikoff, 2001). Standard procedures are described in the county's Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002). Results are used to compute the necessary metrics for calculating the Benthic Invertebrate Index of Biological Integrity (B-IBI) (Karr, 1998; Karr and Chu, 1999), or other metrics and indices as needed.

Volunteer monitors collect macroinvertebrate samples on an annual basis at two LISP stations (MIL010 and BRZ010). County staff oversee volunteer sample collection and perform the sampling if volunteers are unable to visit the station.

Physical habitat objectives

The primary objectives of this component are to describe current stream conditions and trends using physical habitat indicators. Data are used to calculate a range of habitat metrics. Results provide an indication of whether significant habitat limitations are present, serve to characterize baseline conditions, and provide the means to describe changes in habitat condition over an extended time period.

Physical habitat assessments are made using the physical habitat characterization method of the Environmental Monitoring and Assessment Program (EMAP) developed by the US Environmental Protection Agency (EPA). Standard procedures are described in the county's Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002).

Data usage

Data produced by this project are appropriate to meet the analysis objectives listed above. Additionally, data from the LISP are appropriate for a variety of local and regional uses, including submittal to Ecology for 303(d) determinations, incorporation into the Clark County Stream Health Report, and to validate regional stream health models.

Sampling Design

Monitoring Stations

Table 2 lists the LISP station names and descriptions. Figure 1 shows the location of the ten stations.

When selecting stations, subwatershed geology, stream gradient, and drainage area land use were considered in an effort to include a variety of common stream types within Clark County. Approximately 100 potential locations were visited during the selection process. Within this context, LISP stations were located based primarily on long-term accessibility. This led to the selection of stream reaches primarily on public lands where easements or other costly access arrangements were not required.

LISP stations are located on lands owned by school districts, Vancouver/Clark Parks, Clark County Public Works, the State of Washington Department of Natural Resources (DNR), and the City of Camas. One station is located on private land. In most cases, access was secured through a Memorandum of Understanding (MOU) between Clark County and each land-owning entity.

The LISP is not based on a statistical sampling design. Therefore, LISP results are generally not appropriate for statistical extrapolation beyond the individual stations.

Table 2. LISP station names and locations.

Station Name	Waterbody	Station Location Description
BRZ010	Breeze Cr	Breeze Cr upstrm of LaCenter Btms bridge
CGR020	Cougar Cr	Cougar Cr upstrm of NW 119th Street
CHL010	Chelatchie Cr	Chelatchie Cr upstrm of SR 503
CUR020	Curtin Cr	Curtin Cr dnstrm of NE 139th Street
GEE050	Gee Cr	Gee Cr dnstrm of Royle Road
JNS060	Jones Cr	Jones Cr upstrm of Camas water intake
MAT010	Matney Cr	Matney Cr upstrm of NE 68th Street
MIL010	Mill Cr	Mill Cr upstrm of Salmon Creek Avenue
RCN050	Rock Cr	Rock Cr North upstrm of Gabriel Road
WPL050	Whipple Cr	Whipple Cr upstrm of NW 179th Street

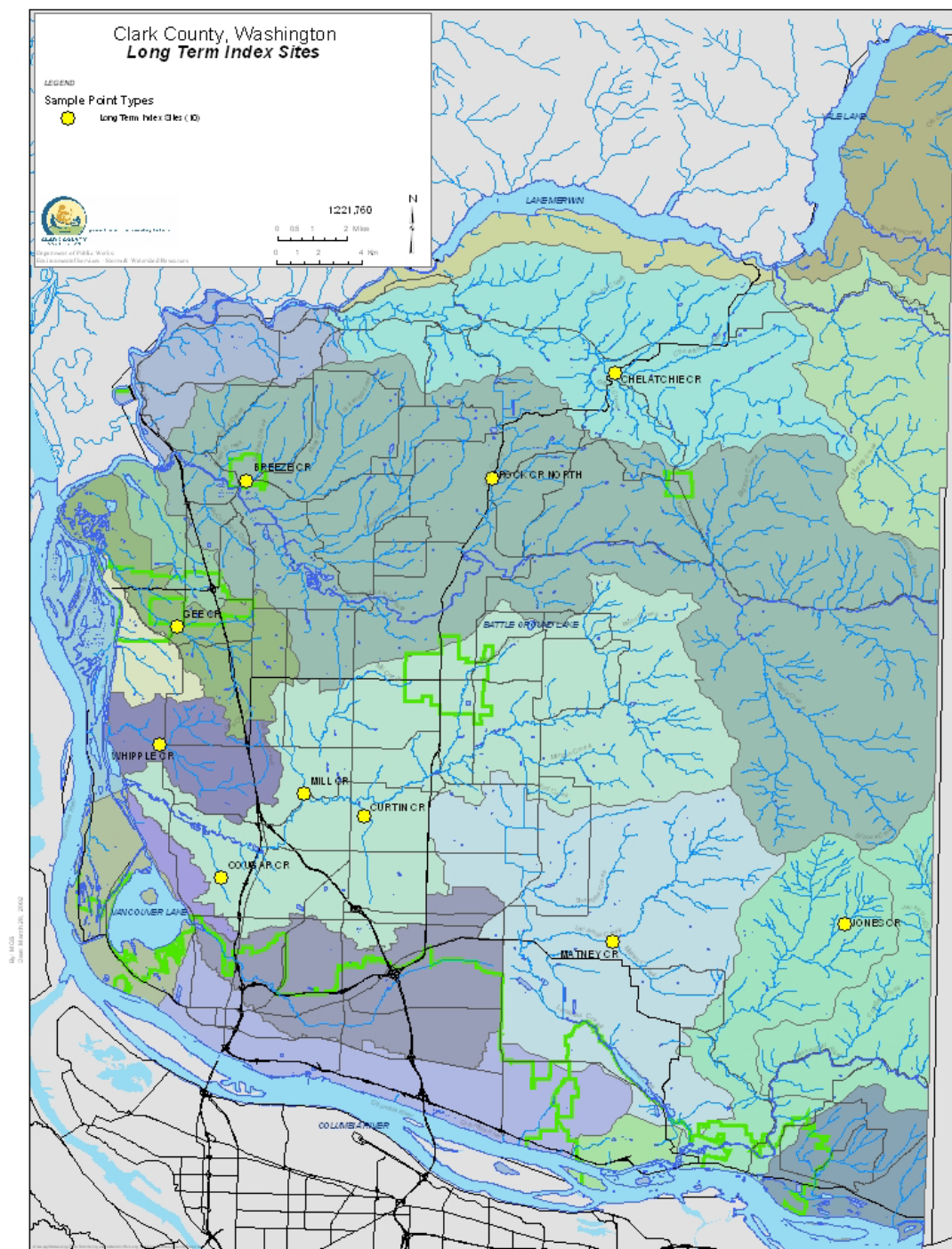


Figure 1. Location of the ten LISP monitoring sites.

Sampling Schedule

Physicochemical samples and measurements are collected at each station on a monthly basis. Tentative monthly sampling dates are randomly selected, but may be revised due to equipment issues, staff availability, or inclement weather. Temperature data loggers are typically deployed during the summer months from May through September. Habitat assessments are generally performed in the summer, during low-flow conditions, and benthic macroinvertebrate samples are collected during August through October.

Sample frequencies and collection methods are detailed in the Field Procedures section.

Representativeness

LISP data are intended to be representative of conditions at each sample station. Water Resources utilizes standard monitoring procedures designed to facilitate the collection of representative samples.

Sampling on randomly-selected dates, sampling well-mixed flow from within the thalweg, and utilizing standard procedures all facilitate the collection of representative water chemistry grab samples. Sampling time is determined by the logistics of visiting all stations on a single day and coordinating with the laboratory for timely analysis of samples. However, in most cases sampling is performed following a standard route and at approximately the same time during each trip to minimize diurnal effects on characteristics which show large diurnal fluctuations (temperature, pH, and dissolved oxygen).

Benthic macroinvertebrate and habitat survey protocols are also designed to facilitate the collection of representative samples. For example, macroinvertebrate sampling is typically conducted moving from downstream to upstream to avoid contamination of downstream samples.

The sample stations themselves were chosen to represent a variety of water body types within Clark County, but are not statistically “representative” of Clark County water bodies as a whole.

Data Comparability

The LISP is designed to gather data that are comparable to other local and regional data. Long-term comparability of LISP data to other data is facilitated by specifying and documenting standard procedures for data collection and analyses.

Physicochemical data are examined in light of applicable state standards and criteria. Physicochemical data are also analyzed using the Oregon Water Quality Index (OWQI), which allows for comparison of project stations to other areas in the Willamette Valley ecoregion.

Benthic macroinvertebrate samples are professionally analyzed to facilitate the calculations of standardized community metrics and indices for direct comparison with regionally collected data. The B-IBI has been used to estimate the effects of a wide variety of land uses on streams in the Northwest including urban and suburban development, forestry, and agriculture. Currently, Seattle and Portland Metro, Seattle Public Utilities, Cities of Portland, Bellevue, Issaquah, and Kent; and Washington, Clackamas, Multnomah, Kitsap, Pierce, Snohomish, and Thurston counties use a common protocol and the B-IBI for management and permitting purposes (Johnson, et al., 2001). Volunteer groups, including the Clark County Volunteer Monitoring program, also collect benthic macroinvertebrate data utilizing the protocol.

Physical habitat data are collected using regionally appropriate protocols developed by the US EPA. Calculated metrics are comparable to those produced by a variety of habitat protocols currently in use in the Pacific Northwest.

Data Quality Objectives

Analytical methods, detection or precision limits, and Measurement Quality Objectives (MQO) for accuracy, precision, and bias are listed in Table 3. MQOs for the LISP are set at generally accepted targets for ambient water quality monitoring projects. Data quality objectives and quality control procedures for laboratory parameters are detailed in the laboratory's quality assurance documents (November, 2001).

Expected precision for EMAP habitat assessment protocols varies by parameter. EMAP precision is addressed in the Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002), and in the EMAP protocol documentation (Kaufmann, et al., 1999).

Collection, preservation, transportation, and storage of samples follow standard procedures designed to reduce most sources of sampling bias. Analytical bias is minimized by adherence to the methods listed in Table 3. The contracted water quality laboratory employs quality control procedures appropriate to the analytical procedures, including analysis of method blanks, matrix spikes, and check standards. The contracted macroinvertebrate laboratory employs quality control procedures appropriate to the analytical procedures for identifying and enumerating macroinvertebrates.

Table 3. LISP analytical methods, resolution, precision, bias, and accuracy.

Characteristic	Method	Resolution/ Reporting Limit	Accuracy	Precision	Bias	Reference
		conc./ units	Units / % error	%RSD	%REC	lab
Temperature (grab)	Thermistor	0.01 °C	± 0.15 °C	NA	NA	
(continuous)	Thermistor (Hobo)	0.02 °C	±0.2°C at 25°C	NA	NA	
(continuous)	Thermistor (DH-21)	0.1 °C	±1.0°C at 0-40°C			
Dissolved oxygen	Membrane electrode	0.01 mg/L	± 0.2 mg/l	NA	±20% (winkler)	
pH	Glass electrode	0.01 units	± 0.2 pH units	NA	NA	
Conductivity	Electrode	4 digits	± 0.5% of reading	NA	NA	
Turbidity (field)	Nephelometric	0.01 NTU	± 2% of reading	NA	NA	
(lab)	Nephelometric	0.20 NTU	25%	10%	5%	EPA 180.1
Total solids	Total residue	10.0 mg/L	25%	10%	5%	EPA 160.3
Ammonia	Colorimetric	0.05 mg/L	25%	10%	5%	EPA 350.1
Nitrate + nitrite	Colorometric/ Cadmium	0.01 mg/L	25%	10%	5%	EPA 353.2
Total phosphorus	Colorometric	0.02 mg/L	25%	10%	5%	EPA 365.1
Fecal coliform	Membrane Filter	2 cfu/100 mL	NA	28%	NA	SM 9222
Benthic macro (taxa richness metric)	4-riffle composite	NA	NA	20%	NA	

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Physical habitat	quantitative survey	NA	NA	varies by metric	NA	
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Field Procedures

Table 4 summarizes the characteristics/indicators, sampling schedules, and sample types for the LISP.

Table 4. Characteristics, schedule, and sample type.

Characteristic/Indicator	Schedule and Frequency	Sample Type	Container/ Preservation
Benthic macroinvertebrates	July-October (annual)	4-riffle composite	1-L LDPE bottle/ 90% ethanol
Habitat survey	July-October (every 5 years)	quantitative survey	
Temperature	1) hourly (May-Sept) 2) monthly	1) data logger 2) field meter	
Dissolved oxygen	monthly	field meter	
pH	monthly	field meter	
Conductivity	monthly	field meter	
Turbidity	monthly	field meter	
Total solids	monthly	grab	250ml LPDE
Ammonia-nitrogen	monthly	grab	250ml LPDE/ sulfuric acid
Nitrate + nitrite-nitrogen	monthly	grab	250ml LPDE
Total phosphorus	monthly	grab	250ml LPDE/ sulfuric acid
Fecal coliform bacteria	monthly	grab	125ml clear sterile

All sampling, analyses, and data management procedures are conducted according to guidelines established or referenced in this QAPP, Standard Methods (APHA, 1992), and the contracts between Clark County and the laboratory facilities.

Equipment calibrations, quality assurance, and field data collection protocols for all data collected by the LISP are described in the county's Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002). All field activities are conducted by field crews consisting of at least two people. Sample containers for laboratory delivery are labeled in indelible ink with the following information:

- Clark County
- LISP
- Site Name
- Date
- Time

Water quality samples are collected in properly preserved bottles prepared by the laboratory, and stored on ice or in the refrigerator until delivery to the lab. Water quality samples are picked up by laboratory personnel within 24 hours of collection. Formal Chain of Custody documentation is maintained for all samples sent to contracted laboratories.

Benthic macroinvertebrate samples are collected in 1-L polyethylene bottles preserved according to laboratory specifications, and refrigerated until delivery to the contracted benthic macroinvertebrate laboratory for analysis.

Logs are kept of all field activities. Logs may consist of standardized field sheets as well as bound log books containing ancillary data and observations. Logs are waterproof and entries made with pencil or indelible ink. Corrections may be made by drawing a single line through the error such that it remains legible, writing the correction adjacent to the error, and initialing the correction. Log entries may include the following, as appropriate:

- Project name and site number
- Identity of field personnel
- Changes in plan
- Antecedent conditions
- Number of samples collected
- Date, time, and description of samples
- Field measurement results
- QC sample identification
- Unusual circumstances affecting data interpretation

Records are cross-checked for consistency between labels, custody documents, data sheets, field logs, and other relevant data. Documentation is archived in WR files.

Field equipment is inspected and maintained by WR staff. Instruments are calibrated according to manufacturer's instructions prior to each field trip or deployment. LISP field measurement parameters, methods, accuracy, and resolution are found in Table 2.

Laboratory Procedures

Monthly water quality samples are transported to the contracted lab by laboratory personnel or courier service within 24 hours after collection. Standard Chain of Custody procedures are followed.

Ammonia, nitrate + nitrite, total phosphorus, total solids, and bacteria analyses are conducted by the laboratory. All procedures are performed according to the laboratory's Ecology-approved quality assurance program and according to accepted conventions for data manipulation and reporting as described in Standard Methods (APHA, 1992). Table 3 shows the constituents measured, analytical methods, and reporting limits.

Analytical results are generally provided within three weeks of receipt of the samples. Data are reported both as digital Excel worksheet files and in .pdf format.

Benthic macroinvertebrate samples are preserved immediately after collection and shipped to the contracted benthic macroinvertebrate laboratory at the conclusion of the field season. Laboratory analyses will be performed in accordance with Ecology-approved methods for standard

taxonomic identifications and metrics (Plotnikoff and Wiseman, 2001). Macroinvertebrates are enumerated and identified to the lowest practicable level, typically to genus and species.

Quality Control

Laboratory QC

Check standards, matrix spikes, analytical duplicates, and blanks are analyzed in accordance with the Quality Assurance Program of the contract water quality laboratory. All QC results are reported to Water Resources along with sample data. Laboratory data reduction, review, and reporting are performed according to the laboratory Quality Assurance Program. Data are assessed for precision, accuracy, and completeness according to the methods described in the laboratory Quality Assurance Program.

The contracted benthic macroinvertebrate laboratory performs QC for laboratory analysis of benthic macroinvertebrate samples, including sorting efficiency and identification verification, according to their quality assurance guidelines. Water Resources has requested that QC for laboratory analysis of benthic macroinvertebrate samples be performed according to Ecology-recommended procedures (Plotnikoff and Wiseman, 2001).

Field QC

Field QC sample types, frequencies, and definitions for LISP *monthly water quality samples* are found in Table 5. A detailed QC sample schedule is on file in WR and is posted in the field prep area for reference when planning field activities. Precision for field sampling and laboratory analysis of bacteria samples is assessed by collecting duplicates for approximately 20% of samples. A standard 10% duplication rate is used for all other water quality parameters. Field measurements are replicated at a 10% rate. Transfer blanks and transport blanks are collected to check for bias introduced by field procedures.

All meters are calibrated and maintained in accordance with the manufacturer's instructions. Check standards for conductivity and turbidity are used to verify the accuracy of field meters. An NIST-traceable thermometer is used to verify the accuracy of temperature sensors. Calibration logs are completed during each calibration and are archived in Water Resources files. Calibration drift in pH meters is checked against pH buffer solutions and dissolved oxygen measurements are verified using a modified Winkler titration in the field. These activities are used to confirm that field instruments are attaining stated accuracy and resolution specifications.

Temperature datalogger QC is performed in accordance with the protocols found in Standard Procedures for Monitoring Activities: Clark County Water Resources Section (2002). Each datalogger is checked for accuracy before and after deployment with a VWR NIST-traceable digital thermometer. This equipment meets stringent accuracy and resolution requirements for temperature measurements and its performance has been documented. Water baths are used giving two check-points that may approximate a range of temperatures encountered during deployment. Additionally, temperature data from each logger are compared with data from an audit thermometer during deployment. Only data that meet pre-and-post deployment and audit criteria will be considered of high enough quality for use.

Table 5. LISP QC sample types, frequencies, and definitions.

Field QC sample type	Frequency	Definition
Field measurement replicate	10% of samples	repeat field meter measurements
Sample duplicate (bacteria) (all other)	20% of samples 10% of samples	duplicate sample collected for laboratory analysis
Transfer blank	Quarterly	D.I. water sample collected in field with sampling equipment
Transport blank	Annually	D.I. water sample prepared in office and carried through field trip
Paired lab sample	Semi-annually	turbidity sample analyzed with field meter, and second sample submitted for lab analysis

Three, 4-riffle replicate benthic macroinvertebrate samples may be collected at 10% of total Water Resources benthic macroinvertebrate sampling stations (including LISP and other projects) per year, if annual budget and time constraints allow. The coefficient of variation among the replicates will be determined for the B-IBI and the taxa richness metric.

It is assumed that the precision of physical habitat measurements made by trained Water Resources staff are similar to those reported by Kauffman et al., 1999. Precision is reported for each measurement and calculated metric in the protocol in Table 6 of the EPA document. To help improve precision, field personnel are trained in the quantitative habitat assessment techniques described in this Standard Procedure, assessment results are checked against other data including qualitative habitat work and biological assessments, and field techniques are reviewed and updated periodically by Water Resources staff.

Corrective Actions

Data quality problems discovered through the collection of QC samples will be addressed as needed through re-calibration, modifications to the field procedures, increased staff training, or by qualifying results appropriately. Documentation of corrective action steps will include problem identification, investigation procedures, corrective action taken, and effectiveness of the corrective action.

Data Management Procedures

Water quality data are reported electronically as Excel spreadsheets and .pdf reports. Benthic macroinvertebrate data are reported by the laboratory in both hard copy and electronic formats.

Digital data files received from contract laboratories are stored as a backup on the Water Resources Q: drive (ntcl01/swwg) under Q:\Monitoring\Data\011161 LISP. Digital files are backed up on CD on an annual basis, and laboratory data packets are archived annually on the county's digital imaging system.

After review, LISP data are stored in the Water Resources relational database. Data are either manually entered or imported. The database is in a SQL Server format, utilizing Access for data entry, editing, analysis, and reporting. Manually entered data are cross-checked by the project manager and/or QC officer for accuracy.

Physical habitat characterization data are stored in hard copy form and also entered into Excel® or other appropriate software formats to facilitate the calculation of habitat metrics. Temperature data from continuous loggers are downloaded, summarized, and stored in electronic format only.

Data Analysis

Standard data analysis procedures utilize Excel, Minitab, and WQ Stat Plus software packages. Statistical trends are evaluated using the non-parametric seasonal Kendall test. Typical graphical displays include time-series and box-and-whisker plots.

Physicochemical water quality data are compared to state and aquatic life use criteria, and used to calculate the Oregon Water Quality Index (OWQI). The OWQI is a regionally-appropriate multi-parameter water quality index that produces a summary score for each parameter as well as an overall aggregate score.

Continuous water temperature data are analyzed using Tempture, a program developed by the Oregon Department of Environmental Quality (DEQ) that calculates summary statistics on continuous data files. Calculated metrics include the 7-day moving average daily maximum water temperature, maximum observed water temperature, dates of occurrence, and duration over specific temperature criteria, e.g. number of days over 64°F.

Ten metrics that describe the community of benthic macroinvertebrates are calculated from the raw benthic macroinvertebrate data. The Benthic-invertebrate Index of Biological Integrity (B-IBI) is a regionally developed index calculated from the set of metric data and used as an overall indicator of stream health (Karr, 1998; Karr and Chu, 1999). The index is used to measure changes in biological communities from activities impacting the stream or watershed. Researchers have found the B-IBI to be sensitive to minor impacts from human disturbance within streams in the Northwest (Cole, 2002; Merritt et al., 1999).

EMAP physical habitat protocols are designed for monitoring applications where robust, quantitative descriptions of reach-scale habitat are desired, such as site classification, trend interpretation, and analysis of possible causes of biotic impairment (Peck et al., 2001). They collect quantifiable measurements about seven general physical habitat attributes important in influencing stream ecology: stream size and channel dimensions, channel gradient, channel substrate size and type, habitat complexity and cover, riparian vegetation cover and structure, anthropogenic alterations, and channel-riparian interaction.

The EMAP physical habitat protocols produce a large amount of data which must be condensed into reach-scale metrics describing various aspects of physical habitat. These include simple statistical summaries, areal cover estimates, proximity-weighted disturbance indices, woody debris abundance, residual pool dimensions, sinuosity, and bed substrate indices.

Raw habitat data are verified, validated, and analyzed using Statistical Analysis Software (SAS) algorithms developed by EPA EMAP staff. Data validation and analysis are performed by Water Resources staff under the guidance of EMAP staff at the USEPA Western Ecology Division's National Health and Environmental Effects Research Laboratory in Corvallis, Oregon. The SAS algorithms calculate approximately 250 habitat metrics in 11 categories. A subset of 49 metrics used most often in multivariate or habitat analyses are recommended by EPA, including a balanced set of 18 "most important" metrics.

Audits and Reports

Audits

The project manager and QC officer periodically review the field data, methods, lab results, and data management activities to make an assessment of the program and identify corrective actions or method revisions.

Reports

Reports address project methods, discuss results by indicator and by site, summarize project findings, describe any significant data quality problems, and suggest modifications for future monitoring. Peer review is conducted by WR section staff.

During the initial implementation, discussion focuses on characterizing baseline conditions at the LISP sites. As sufficient data are accumulated, the report focus will shift to describing possible trends in stream health.

LISP reports are generally incorporated, referenced, or summarized in the county's annual NPDES permit compliance report to Ecology. Executive summaries, and full reports as warranted, are placed on the county's website to facilitate dissemination of information to the public.

Data Review, Verification, and Validation

During each sample trip, field crews review field and sample logs to confirm that all necessary field measurements and samples have been collected. Laboratory QC results are reviewed and verified by NCA staff and documented in data reports to Water Resources. Upon receipt, laboratory data are reviewed for errors, omissions, and data qualifiers prior to data entry.

Data verification involves examination of QC results analyzed during the project to provide an indication of whether the precision and bias MQOs have been met. To evaluate whether precision targets have been met, pairs of duplicate sample results are pooled and an estimate of standard deviation is calculated. This estimate, divided by the mean concentration of the duplicate results and converted to percent, is used to judge whether the %RSD target has been met.

To evaluate whether bias targets have been met, the mean percent recovery of the check standards should be within +/- %bias target of the true value (e.g. true value +/- 20%). Unusually high blank results indicate bias due to contamination that may affect low-level results. To evaluate whether the target for reporting limit has been met, results are examined to determine if any of the values exceed the required reporting limits.

Data validation consists of a detailed examination of the complete data package using professional judgment to assess whether the procedures in the SP's and QAPP have been followed. Data validation is performed by the project manager and QC coordinator.

Data Quality Assessment

Taking into account the results of data review, verification, and validation, an assessment will be made as to whether the data are of sufficient quality to attain project objectives

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